

BASELMANS ET AL. -- 09/905,198
Client/Matter: 081468-0281487

IN THE CLAIMS:

This listing of claims will replace all prior versions, and listings, of claims in the application:

1. (Currently Amended) A mask for use in a lithographic apparatus, the mask comprising a plurality of isolated areas that contrast with a background and represent features to be printed in manufacture of a device, said isolated areas being arranged in an array such that at least part of each isolated area is adjacent to at least part of at least one other isolated area in the array; and

a plurality of non-printing assist features smaller than and distinct from said isolated areas, at least one of said plurality of assist features being positioned so as to make an aerial image of one of said isolated areas more similar to an aerial image of another of said isolated areas, and positioned so as to make an aerial image of said array more symmetric

wherein an axis of symmetry of said at least one assist feature, an axis of symmetry of the array, and an axis of symmetry of at least one of said isolated areas are substantially coincident.

2. (Currently Amended) A mask according to claim 1, wherein ~~said array is disposed within at least one unit cell and said assist features are positioned so as to make an aerial image of each of said at least one unit cell more symmetric~~ said mask comprises a plurality of unit cells, each having substantially the same shape, said array being disposed within one of said unit cells.

3. (Currently Amended) A mask according to claim 2, wherein for at least one regular unit cell of the mask, at least one ~~of said isolated areas~~ isolated area within the regular unit cell is positioned proximate at least one of the points of the regular unit cell and at least one assist feature is positioned proximate a point of the regular unit cell not occupied by the isolated areas.

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4. (Currently Amended) A mask according to claim 3, wherein said isolated areas are positioned at three corners of a rectangular unit cell and at least one of said assist features are is positioned at the fourth corner.

5. (Currently Amended) A mask according to claim 1 wherein said ~~assist features are~~ at least one assist feature is positioned so as to reduce the effect of at least one odd aberration in a wavefront produced by said array when illuminated by exposure radiation in said lithographic apparatus.

6. (Currently Amended) A mask according to claim 1 wherein said assist features are positioned ~~along at least part of the edge of said array so as to make the surroundings of features at or near the edge of the array more similar to the surroundings of features in the interior of the array at a periphery of said array so as to increase a similarity between aerial images of isolated areas near the periphery of the array and an aerial image of an isolated area near a center of the array.~~

7. (Currently Amended) A mask according to claim 1 wherein ~~assist features are~~ said at least one assist feature is positioned so as to reduce the effect of at least one of the group consisting of three-wave aberration and comatic aberration in a wavefront produced by said array when illuminated by exposure radiation in said lithographic apparatus.

8. (Previously Presented) A mask according to claim 1 wherein said assist features have a contrast to the background of said mask substantially equal to a contrast to the background of said mask of said isolated areas.

9. (Previously Presented) A mask according to claim 1 wherein said isolated areas are more transparent to exposure radiation of said lithographic apparatus than said background.

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10. (Previously Presented) A mask according to claim 1 wherein said isolated areas are more reflective of exposure radiation of said lithographic apparatus than said background.

11. (Previously Presented) A mask according to claim 1 wherein said isolated areas are configured to impart a different phase shift than said background.

12. (Original) A mask according to claim 1 wherein said assist features are smaller than a critical dimension of said mask.

13. (Previously Presented) A mask according to claim 12 wherein said assist features are smaller than a resolution limit of said lithographic apparatus.

14. (Currently Amended) A method of making a mask for use in a lithographic apparatus, the method comprising:

defining a plurality of isolated areas that contrast with a background and represent features to be printed in manufacture of a device, said isolated areas being arranged in an array such that at least part of each isolated area is adjacent to at least part of at least one other isolated area in the array; and

defining a plurality of non-printing assist features smaller than and distinct from said isolated areas, at least one of said plurality of assist features being positioned so as to make an aerial image of one of said isolated areas more similar to an aerial image of another of said isolated areas, and positioned so as to make an aerial image of said array more symmetric

wherein an axis of symmetry of said at least one assist feature, an axis of symmetry of the array, and an axis of symmetry of at least one of said isolated areas are substantially coincident.

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15. (Currently Amended) A method according to claim 14, wherein said defining a plurality of non-printing assist features comprises:

determining at least one wavefront aberration in an aerial image to be produced in said lithographic apparatus by said array; and

~~determining positions, shapes and sizes for~~ a position, shape, and size for at least one of said plurality of non-printing assist features so as to reduce said at least one wavefront aberration in said aerial image.

16. (Currently Amended) A method according to claim 15 wherein said ~~positions for said plurality of non-printing assist features are~~ position is determined so as to reduce at least one of the group consisting of three-wave aberration and comatic aberration.

17. (Currently Amended) A method of manufacturing a device using a lithographic apparatus comprising:

imaging irradiated portions of a mask onto target portions of a substrate, wherein said mask is provided with a plurality of isolated areas that contrast with a background and represent features to be printed in manufacture of a device, said isolated areas being arranged in an array such that at least part of each isolated area is adjacent to at least part of at least one other isolated area in the array, and a plurality of non-printing assist features ~~smaller than and distinct from~~ at least one of said plurality of assist features being positioned so as to make an aerial image of one of said isolated areas more similar to an aerial image of another of said isolated areas, and positioned so as to make an aerial image of said array more symmetric

wherein an axis of symmetry of said at least one assist feature, an axis of symmetry of the array, and an axis of symmetry of at least one of said isolated areas are substantially coincident.

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18. (Original) A method according to claim 16 wherein said device includes a memory array.

19. (Withdrawn) A device manufactured according to the method of claim 17.

20. (Previously Presented) A method according to claim 17 wherein said imaging includes directing a beam patterned by the mask onto the target portions, and wherein said assist features have a largest dimension less than 50% of a principal wavelength of said beam.

21. (Previously Presented) A method according to claim 20 wherein the largest dimension is in the range of from 30 to 40% of a principal wavelength of said beam.

22. (Currently Amended) A mask for use in a lithographic apparatus, the mask comprising:

a plurality of isolated areas that contrast with a background and represent features to be printed on a substrate, said isolated areas being substantially mutually identical and arranged in an array such that at least part of each isolated area is adjacent to at least part of at least one other isolated area in the array; and

a plurality of assist features that are smaller than a resolution limit of said apparatus, at least one of said plurality of assist features being arranged adjacent to a first edge of a first isolated area of the array and to a second edge of another isolated area, the assist features being positioned with respect to the isolated areas such that a difference between intensity profiles of features in a mask image that are based on mutually adjacent ones of the plurality of isolated areas is reduced

wherein the shortest distance between the first and second edges is at least twice the shortest distance from (A) the first edge to (B) an edge of the first isolated area opposite the first edge.

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23. (Original) A mask according to claim 22, wherein said mask image is an image developed in a layer of photosensitive material.

24. (Previously Presented) A mask according to claim 1 wherein said assist features are configured to impart a different phase shift than said background.

25. (Previously Presented) A mask according to claim 1 wherein said isolated areas are configured to impart a different attenuation than said background.

26. (Previously Presented) A mask according to claim 1 wherein said assist features are configured to impart a different attenuation than said background.

27. (Previously Presented) A mask according to claim 1 wherein the elements of at least one of the group consisting of said assist features and said isolated areas is configured to impart a different one of at least one of the group consisting of phase shift, attenuation and tone than said background.

28. (Currently Amended) A computer program product including machine-readable instructions describing a method of making a mask for use in a lithographic apparatus, said method comprising:

defining a plurality of isolated areas that contrast with a background and represent features to be printed in manufacture of a device, said isolated areas being arranged in an array such that at least part of each isolated area is adjacent to at least part of at least one other isolated area in the array; and

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defining a plurality of non-printing assist features smaller than and distinct from said isolated areas, at least one of said plurality of assist features being positioned so as to make an aerial image of one of said isolated areas more similar to an aerial image of another of said isolated areas, and positioned so as to make an aerial image of said array more symmetric

wherein an axis of symmetry of said at least one assist feature, an axis of symmetry of the array, and an axis of symmetry of at least one of said isolated areas are substantially coincident.

29. (Currently Amended) The computer program product of claim 28, wherein said defining a plurality of non-printing assist features comprises:

determining at least one wavefront aberration in an aerial image to be produced in said lithographic apparatus by said array; and

determining ~~positions, shapes and sizes for~~ a position, shape, and size for at least one of said plurality of non-printing assist features so as to reduce said at least one wavefront aberration in said aerial image.

30. (Currently Amended) The computer program product of claim 29, wherein said ~~positions for said plurality of non-printing assist features are~~ position is determined so as to reduce at least one of the group consisting of three-wave aberration and comatic aberration.

31. (Currently Amended) The computer program product of claim 29, wherein said determining at least one wavefront aberration in an aerial image to be produced includes calculating said at least one wavefront aberration based on a definition of the plurality of isolated areas and a definition of at least one of the plurality of non-printing assist features.

32. (Previously Presented) The computer program product of claim 28, wherein said isolated areas are defined to impart a different phase shift than said background.

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33. (Previously Presented) The computer program product of claim 28, wherein said assist features are defined to impart a different phase shift than said background.

34. (Previously Presented) The computer program product of claim 28, wherein said isolated areas are defined to impart a different attenuation than said background.

35. (Previously Presented) The computer program product of claim 28, wherein said assist features are defined to impart a different attenuation than said background.

36. (Previously Presented) The computer program product of claim 28, wherein the elements of at least one of the group consisting of said assist features and said isolated areas are defined to impart a different one of at least one of the group consisting of a phase shift, attenuation and tone than said background.

37. (Currently Amended) A mask for use in a lithographic apparatus, the mask comprising an array having a plurality of isolated areas that contrast with a background and represent features to be printed on a substrate, said isolated areas being arranged such that at least part of each isolated area is adjacent to at least part of at least one other isolated area; and

a plurality of non-printing assist features smaller than said isolated areas, at least one of said plurality of non-printing assist features being arranged adjacent to a first edge of a first isolated area of the array and to a second edge of another isolated area,

wherein said plurality of assist features are positioned to increase a symmetry of an aerial image of said array the shortest distance between the first and second edges is at least twice the shortest distance from (A) the first edge to (B) an edge of the first isolated area opposite the first edge.

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38. (Previously Presented) The mask according to claim 37, wherein said plurality of non-printing assist features are positioned to increase rotational symmetry of an aerial image of said array.

39. (Previously Presented) The mask according to claim 37, wherein said plurality of non-printing assist features are positioned to increase reflexive symmetry of an aerial image of said array.

40. (Previously Presented) The mask according to claim 37, wherein said plurality of non-printing assist features are positioned to increase translational symmetry of an aerial image of said array.

41. (Previously Presented) The mask according to claim 37, wherein said plurality of non-printing assist features are positioned to increase symmetry of an aerial image of said array along an axis of the aerial image.

42. (Previously Presented) The mask according to claim 37, said mask comprising a plurality of substantially identical unit cells, each having a unit cell array disposed therein that includes a plurality of isolated areas that contrast with a background and represent features to be printed on a substrate, said isolated areas of said unit cell array being arranged such that at least part of each isolated area of the unit cell array is adjacent to at least part of at least one other isolated area of the unit cell array; and

a plurality of non-printing assist features smaller than said isolated areas,

wherein said plurality of non-printing assist features are positioned to increase a symmetry of an aerial image of each of said unit cell arrays.

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43. (Previously Presented) The mask according to claim 37, wherein each of said unit cells includes at least one isolated area positioned proximate a vertex of the unit cell and at least one non-printing assist feature positioned proximate another vertex of the unit cell.

44. (Previously Presented) The mask according to claim 37, wherein each of said unit cells is substantially rectangular and includes at least one isolated area positioned proximate to a corresponding one of each of three corners of the unit cell and at least one non-printing assist feature positioned proximate to the fourth corner of the unit cell.

45. (Previously Presented) The mask according to claim 37, wherein said isolated areas are more transparent to the exposure radiation of said lithographic apparatus than said background.

46. (Previously Presented) The mask according to claim 37, wherein said isolated areas are more reflective of the exposure radiation of said lithographic apparatus than said background.

47. (Previously Presented) The mask according to claim 37, wherein said isolated areas are configured to impart a different phase shift than said background.

48. (Previously Presented) The mask according to claim 37, wherein said assist features are smaller than a resolution limit of said lithographic apparatus.

49. (Currently Amended) A method of making a mask for use in a lithographic apparatus, the method comprising:

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defining a plurality of isolated areas that contrast with a background and represent features to be printed in manufacture of a device, said isolated areas being arranged in an array such that at least part of each isolated area is adjacent to at least part of at least one other isolated area in the array; and

defining a plurality of non-printing assist features smaller than said isolated areas,

wherein said defining a plurality of non-printing assist features includes ~~determining positions, shapes and sizes for said plurality of assist features to increase a symmetry of an aerial image of said array~~ arranging at least one of said plurality of non-printing assist features to be adjacent to a first edge of a first isolated area of the array and to a second edge of another isolated area, and

wherein the shortest distance between the first and second edges is at least twice the shortest distance from (A) the first edge to (B) an edge of the first isolated area opposite the first edge.

50. (Previously Presented) The method of making a mask according to claim 49, wherein said defining a plurality of assist features comprises:

determining at least one wavefront aberration in an aerial image to be produced in said lithographic apparatus by said array; and

determining positions, shapes and sizes for said plurality of non-printing assist features so as to reduce said at least one wavefront aberration.

51. (Previously Presented) The method of making a mask according to claim 50, wherein said determining at least one wavefront aberration in an aerial image to be produced includes calculating said at least one wavefront aberration based on a definition of the plurality of isolated areas and a definition of the plurality of non-printing assist features.

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52. (Previously Presented) The method of making a mask according to claim 49, wherein said isolated areas are defined to be more transparent to the exposure radiation of said lithographic apparatus than said background.

53. (Previously Presented) The method of making a mask according to claim 49, wherein said isolated areas are defined to be more reflective of the exposure radiation of said lithographic apparatus than said background.

54. (Previously Presented) The method of making a mask according to claim 49, wherein said isolated areas defined to impart a different phase shift than said background.

55. (Previously Presented) The method of making a mask according to claim 49, wherein said assist features are defined to be smaller than a resolution limit of said lithographic apparatus.

56. (Currently Amended) The mask according to claim 22, said mask comprising a plurality of substantially identical unit cells, each having a unit cell array disposed therein that includes a plurality of isolated areas that contrast with a background and represent features to be printed on a substrate, said isolated areas of said unit cell array being arranged such that at least part of each isolated area of the unit cell array is adjacent to at least part of at least one other isolated area of the unit cell array; and

a plurality of non-printing assist features smaller than said isolated areas;

~~wherein said plurality of non-printing assist features are positioned to increase a symmetry of an aerial image of each of said unit cell arrays.~~

57. (Previously Presented) The mask according to claim 22, said mask comprising a plurality of regular unit cells, wherein each of said unit cells includes at least one of the plurality

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of isolated areas positioned proximate a vertex of the unit cell and at least one of the plurality of assist features positioned proximate another vertex of the unit cell.

58. (Previously Presented) The mask according to claim 22, said mask comprising a plurality of substantially rectangular unit cells, wherein each of said unit cells includes at least one of the plurality of isolated areas positioned proximate to a corresponding one of each of three corners of the unit cell and at least one of the plurality of assist features positioned proximate to the fourth corner of the unit cell.

59. (Previously Presented) ~~A mask for use in a lithographic apparatus, the mask~~ method of manufacturing a device using a lithographic apparatus, said method comprising:

an array having imaging irradiated portions of a mask onto target portions of a substrate, wherein said mask is provided with a plurality of isolated areas that contrast with a background and represent features to be printed on a substrate, said isolated areas being arranged such that at least part of each isolated area is adjacent to at least part of at least one other isolated area[;] , and a plurality of non-printing assist features smaller than said isolated areas, at least one of said plurality of assist features being arranged adjacent to a first edge of a first isolated area of the array and to a second edge of another isolated area,

~~wherein said plurality of assist features are positioned to increase a symmetry of said array on an axis of symmetry~~ the shortest distance between the first and second edges is at least twice the shortest distance from (A) the first edge to (B) an edge of the first isolated area opposite the first edge.

60. (Currently Amended) The mask according to claim ~~[[59]]~~ 37, wherein said plurality of non-printing assist features are positioned to increase rotational symmetry of said array.

61. (Currently Amended) The mask according to claim ~~[[59]]~~ 37, wherein said plurality of non-printing assist features are positioned to increase reflexive symmetry of said array.

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62. (Currently Amended) The mask according to claim ~~[[59]]~~ 37, wherein said plurality of non-printing assist features are positioned to increase translational symmetry of said array.

63. (Currently Amended) The mask according to claim ~~[[59]]~~ 37, wherein said plurality of non-printing assist features are positioned to increase symmetry of said array along an axis of the array.

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